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SUBMAXILLARY GLANDS OF PILOCARPINE-TREATED
WISTAR RATS, COTTON RATS, AND CHINCHILLAS

SCHOOL OF AVIATION MEDICINE
RANDOLPH AIR FORCE BASE, TEXAS

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THE SODIUM AND POTASSIUM CONTENT OF THE
PARATHYROID GLANDS OF PLOCARPINE-TREATED
WISTAR-KRATZ RATS, COTTON RATS, AND CHINCILLA



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**THE SODIUM AND POTASSIUM CONTENT OF THE SUBMAXILLARY GLANDS OF
PILOCARPINE-TREATED WISTAR RATS, COTTON RATS, AND CHINCHILLAS**

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RANDOLPH AFB, TEXAS
April 1959**

THE SODIUM AND POTASSIUM CONTENT OF THE SUBMAXILLARY GLANDS OF PILOCARPINE-TREATED WISTAR RATS, COTTON RATS, AND CHINCHILLAS

Previous human experimentation in this laboratory (1) has shown that, under prolonged stimulation, salivary volume levels remain unchanged, while salivary sodium increases and potassium decreases with the passage of time. The present experiments were then designed to study the concentrations of sodium and potassium within the submaxillary glands of different animals under various treatment conditions. Of primary interest was the question of whether, under strenuous prolonged stimulation, the glands were depleted of these cations or if the source of these elements was sufficient to maintain levels within the glands.

PROCEDURE

One experiment was conducted for each of the three animal types. In each experiment, untreated animals were considered as the control group and the experimental animals were given graded subcutaneous doses of pilocarpine to produce salivary flow. The animals were sacrificed at specified time periods after the initial dosage, the submaxillary glands were extirpated, weighed, and a portion homogenized and analyzed for sodium and potassium.

Every gland, right and left, was analyzed. Immediately upon extirpation, a section of each gland was removed, cleared of gross blood, weighed, and placed in 1.0 ml. of ion-exchange water in a ground-glass homogenizer driven by a Sargent cone drive stirring motor. After complete homogenization, 2.5 ml. of 4 percent trichloroacetic acid were added, the mixture was shaken thoroughly and was allowed to stand for at least 20 minutes; 6.5 ml. of ion-exchange water were then added; the mixture was shaken thoroughly and centrifuged at 3,000 r.p.m. for 10 minutes. Aliquots of the supernate were aspirated into

the hydrogen-oxygen flame of a Beckman DU flame spectrophotometer equipped with photo-multiplier and spectral energy recording adapter. Statistical analyses were performed on the resultant data and the ratio of the two variables, Na/K, was determined and included in the statistical analyses. The total weight for each gland was also recorded and the means, mean differences, ranges, and standard deviations were computed. In addition, statistical tests were performed to determine if differences in gland weight existed between the right and left glands of the three groups of animals.

RESULTS

Wistar rats

A total of 50 animals was included in this experiment. The treatment groups were as follows: T_1 —20 animals received no drug and served as control animals; T_2 —10 animals received pilocarpine (10 mg./kg. body weight) and were sacrificed 30 minutes later; T_3 —10 animals received pilocarpine (20 mg./kg. body weight) and were sacrificed 30 minutes later; and T_4 —10 animals received pilocarpine (40 mg./kg. body weight), a repeated dose of the same size 15 minutes later, and were sacrificed 30 minutes after the initial dose.

For each of the three variables under study, Na, K, and Na/K, no significant difference was found in the means for the right and left glands.

Highly significant differences were found in the sodium levels when the means for the four treatments were compared (table I). When pilocarpine was administered, the mean levels of sodium in the glands at the time of sacrifice were greater than the mean sodium value for the control animals. These increases were statistically significant ($P < .01$). The effect of the drug was roughly linear up to a dosage of 20 mg./kg. body weight, but when

the dosage was increased to 80 mg./kg. (T_4) the mean was less than the mean for T_3 . This decrease was not significant but it does point out that the effect of the drug tended to level off at a dosage in the vicinity of that given in T_3 .

The glands of the pilocarpine-treated animals contained significantly less potassium than did the glands of the control animals ($P < .01$). The potassium means (table I) decreased from the control mean in approximately linear fashion for the dosages of 10 and 20 mg./kg. These decreases were significant at the 1 percent level. When a dose of 80 mg./kg. was administered, however, the potassium mean was higher than the mean for the 20 mg./kg. dose. Testing of these two means revealed that this reversal in the linear trend was significant ($P < .05$).

Cotton rats

Only 12 animals (6 controls and 6 experimental) were employed in this experiment. The 6 control animals (T_1) received no drug, while those of the experimental group (T_2) were given pilocarpine (40 mg./kg. body weight) and were sacrificed after 30 minutes.

A significant difference ($P < .01$) was found in the two gland means for sodium. The sodium level of the left glands was higher than that for the right glands. For potassium, no significant difference was found in the mean content of the right and left glands. For Na/K, the mean for the left gland was significantly

higher ($P < .05$) than the mean for the right gland.

A highly significant difference was found in the sodium levels when the means for the two treatment groups were compared. For those animals receiving pilocarpine, the mean sodium level was higher than that for the control animals (table II).

For those animals which had been given pilocarpine, the potassium mean was lower than the mean for the control animals. The difference between the two means was highly significant.

For Na/K, a highly significant difference was found between the means for the two treatments. The mean ratio was greater for those animals which had been given pilocarpine.

Chinchillas

Eighteen chinchillas were divided into three groups for this experiment: 6 animals (T_1) received no drug and served as controls; 6 animals (T_2) received pilocarpine (40 mg./kg. body weight) and were sacrificed after 30 minutes; 6 animals (T_3) received pilocarpine (40 mg./kg. body weight) and were sacrificed after 1 hour.

For each of the three variables studied, no significant difference was found in means for the right and left glands.

For sodium, highly significant differences were found in the means for the three treatment groups. From the table of means (table III) it can be seen that the sodium means for the

TABLE I

Wistar rats: Means, standard deviations, and sample sizes by treatment

	Means				S.D.†
	Pilocarpine dosage				
	None (controls)	10 mg./kg. (T ₂)	20 mg./kg. (T ₃)	80 mg./kg. (T ₄)	
Na*	1.44	1.81	2.36	2.28	.22
K*	4.12	3.20	2.40	2.68	.28
Na/K	0.35	0.57	0.99	0.87	.12
n	20	10	10	10	

*Milligram per gram of gland.

†This between animal standard deviation is based on the average gland weight per animal.

treated animals were higher than the mean for the untreated animals. These increases were significant at the 1 percent level. For identical amounts of pilocarpine, the mean sodium level was lower when sacrifice took place after 1 hour than when it took place after 30 minutes. This decrease in the sodium mean when sacrifice time was increased was significant at the 1 percent level.

For potassium, highly significant differences were found in the means for the three treatments. For both groups of treated animals, the potassium means were significantly less than the mean for the control group ($P < .01$), and the effect was approximately linear. For identical doses of pilocarpine (T_2 and T_3) the potassium mean was significantly lower for the animals sacrificed after 1 hour than for those sacrificed after 30 minutes ($P < .05$).

For Na/K, when the treatment means were compared, highly significant differences were found. The ratio of sodium to potassium was greater for the animals given pilocarpine than for the control animals. The differences between these means and the control mean were significant ($P < .01$). The mean ratio tended to level off between sacrifice times of 30 minutes and 1 hour, the difference between these two means not being significant.

Total gland weight

When the glands were removed from the animals, the total gland weights were recorded before a section of each gland was removed for homogenization. To determine if differences existed between the weights of the right and left glands, a t-test was performed comparing the two glands for each animal group. The results indicated no significant weight difference between the right and left glands of any animal group. The mean single gland weight for each animal type was as follows: Wistar rats, 196.5 mg.; cotton rats, 160.7 mg.; and chinchillas, 93.3 mg.

DISCUSSION

For all of the experiments mean sodium levels in the glands of those animals given pilocarpine were found to be significantly higher than in the untreated animals. These results indicate that, when salivary flow is stimulated by pilocarpine, the source of sodium

TABLE II

Cotton rats: Means, standard deviations, and sample sizes by treatment

	Means		S.D. †
	Controls (T_1)	Pilocarpine 40 mg./kg. (T_2)	
Na*	1.23	1.68	.11
K*	4.43	2.54	.16
Na/K	0.281	0.665	.05
n	6	6	

*Milligrams per gram of gland.

†This between animal standard deviation is based on the average gland weight per animal.

TABLE III

Chinchillas: Means, standard deviations, and sample sizes by treatment

	Means			S.D. §
	Pilocarpine dosage			
	None (controls)	40 mg./kg. (T ₂)*	40 mg./kg. (T ₃)†	
Na ‡	1.45	2.39	1.83	.22
K ‡	3.17	2.36	1.84	.39
Na/K	0.47	1.06	1.03	.25
n	6	6	6	

*Sacrificed after 30 minutes.

†Sacrificed after 1 hour.

‡Milligrams per gram of gland.

§This between animal standard deviation is based on the average gland weight per animal.

to the gland is such that the sodium level within the gland is not only maintained but is increased significantly. The potassium source of the gland is evidently not capable of maintaining the gland potassium level under pilocarpine stimulation and, consequently, gland potassium decreases significantly. These trends tend to reverse or to level off at certain dosage levels or beyond certain sacrifice times.

The findings of this experiment are in accord with previous results with other animals. Under chorda tympani stimulation, the cat's submaxillary gland was able to maintain its potassium

content at the normal level but, when stimulated with pilocarpine, the gland lost potassium (2). It has also been shown (3) that the submaxillary glands of both dogs and cats under chorda tympani stimulation gained water and sodium without a substantial loss of other elements. Under pilocarpine, however, the glands gained water and sodium but lost potassium.

SUMMARY

The effect of pilocarpine dosage on submaxillary gland sodium and potassium was determined in three separate experiments utilizing Wistar rats, cotton rats, and chinchillas.

Mean sodium levels were in all instances significantly higher in the treated animals than in the controls while the reverse held true for gland potassium content. The Na/K

ratio was consistently higher in the pilocarpine-treated groups.

These results suggest that the source of sodium for the functioning gland greatly exceeds that of potassium.

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